NATIONAL BUREAU OF STANDARDS REPORT

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QUARTERLY REPORT

ON

EVALUATION OF REFRACTORY QUALITIES OF CONCRETES FOR JET AIRCRAFT WARM UP, POWER CHECK, AND MAINTENANCE APRONS

by

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Mineral Products Division

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QUARTERLY REPORT
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EVALUATION OF REFRACTORY QUALITIES OF CONCRETES
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Technical Requirements

The preparation and mixing of each batch of concrete of the same composition must be so controlled as to result in a nearly constant air and water content.

The concretes must be of such a consistency as to result in a 2-inch slump when tested in accordance with ASTM Method Designation: C143-39 [1]. If a concrete is not sufficiently workable to be placed when designed for a 2-inch slump then this requirement may be changed to permit proper placing.

The concretes must develop a flexural strength of 600-650 psi after a twenty-eight day curing period. If the required strength is not developed with a 9-sack per cubic yard mix it shall be reported as such.

Resistance to destruction, when exposed to rapidly increasing and fluctuating temperatures, is necessary.

The compressive strength shall be determined on each concrete after the twenty-eight day curing period.

I. INTRODUCTION

The objective of the investigation is the determination of the physical properties of refractory concretes, and from this information to evaluate their suitability for jet aircraft warm up, power check and maintenance aprons.

II. PREPARATION AND TESTING

Cements. The physical and chemical properties of the three types of cement included in this project were previously reported [2].

Aggregates. The properties of the three dense aggregates used during this quarter were previously reported [3].

Concretes. Seven concretes were designed using portland cement with Bluestone and olivine, respectively, portland-pozzolan with Bluestone, olivine, and crushed building brick, respectively, and high alumina hydraulic cement with Bluestone and crushed building brick, respectively. The properties determining the proportion, by weight, of fine to coarse aggregate in the concretes were determined from a previous report [3].

Previous work indicated that the concretes designed with olivine aggregates would develop the required flexural strength with less than a 9-sack cement content [3]. However since this concrete did not develop the required strength as given in table 2 of this report other mixes with this aggregate were designed with a 9-sack cement content. The results of strength tests on concretes containing the aggregates Bluestone or crushed building brick justified the increase to a 9-sack cement content for these aggregates.

The vinsol resin was added to increase the workability of the concretes. Water was added in sufficient amounts to yield the required slump of 2 inches.

Five sets of test specimens were fabricated from each of the seven concrete mixes. Each set consists of one slab 24 x 24 x 2 1/4 inches, two prisms 16 x 4 x 3 inches, 1 beam 36 x 6 x 6 inches, 1 beam 20 x 6 x 6 inches, 1 plate 8 x 8 x 1 inch. Four cylinders were cast from one of the several batches of each concrete. The method of fabricating, curing, and heat treating has been described in a previous report [2]. A detailed description of the method of testing for all properties of the concretes, with the exception of the flexural strength, were given in previous report [2].

However, a tilt-drum mixer with a capacity of 5 cubic-feet replaced the 3 cubic foot mixer formerly used. This change made it possible to fabricate all specimens of one concrete within the same day.

Flexural strength was determined in accordance with ASTM Designation: C78-44 [1]. The results of these tests are given in table 2.

III. RESULTS

The high cement content as calculated for concretes containing the high alumina cement, table 2, could have been caused by excessive bleeding and, therefore, may be questionable.

The water and air contents for all batches of the same concretes was controlled as cl sely as possible under existing conditions. The actual amount of water added was determined by slump tests. The entrained air was kept below five percent. Air contents above that amount tend to decrease the strength of the concretes.

The slump of 2 inches indicated satisfactory workability for all concretes except those containing the high alumina cement. Results indicated that concretes of this type required a slump of at least 4 inches to be sufficiently workable. One manufacturer of high-alumina hydraulic cement suggests that their product does not produce a fatty lubricant for the aggregates as does portland cement and the results of a slump test are not comparable for the two types.

Table 2 gives insufficient results for any definite conclusions but from the limited amount of work completed the following statements may be made.

There is no direct relation between the compressive and flexural strengths of concretes of different compositions.

None of the concretes thus far tested developed the required flexural strength of 600-650 psi after the 28-day curing period. The pozzolan-olivine concrete reached the required strength after a 250°C five-hour heating but decreased upon heating to 500°C. The other concretes decreased in flexural strength with increasing heat treatments.

The resistance to abrasion decreased with increasing heat treatments.

The linear measurements of concrete specimens indicate that permanent expansion occurs upon heating.

Laboratory identification a/
Z-O-A
Z-O-B
Z-O-C
Z-O-D
P-O-A
P-O-B
P-O-C
Z-BS-A
Z-BS-B
Z-BS-C
Z-BS-D
P-BS-A
P-BS-B
P-BS-C
L-BS-A
L-BS-B
L-BS-C
L-BS-D
Z-B-A c/
Z-B-B
Z-B-C
L-B-A
L-B-B
L-B-C

a/ The first lette
The second lett
The third lette
cast the r

b/ All specimens f
in poorly

c/ Cement : Fine :

Table 1. Properties of the fresh concretes

Laboratory identification a/	Proportions by weight. Cement to fine and to coarse aggregate	Cement content	Vinsol resin by weight of cement	Water Content	Air Content	Slump	Weight	Workability Notes
		Sacks/yd^3 of concrete	%	Gal/yd^3 of concrete	%	in.	lb/ft^3	
Z-O-A	1:0.58:3.40	8.5	0.02	53.5	0.00	1.75	164.0	Very good - rich
Z-O-B	1:0.58:3.40	8.5	0.02	53.0	0.00	2.00	164.0	Very good - rich
Z-O-C	1:0.58:3.40	8.5	0.02	52.7	0.00	2.00	164.0	Very good - rich
Z-O-D	1:0.58:3.40	8.5	0.02	53.0	0.00	1.87	164.0	Very good - rich
P-O-A	1:0.55:3.24	8.9	0.02	47.9	1.56	2.00	163.0	Very good, sticky, rich
P-O-B	1:0.55:3.24	8.9	0.02	48.3	1.55	2.00	162.0	Very good, sticky, rich
P-O-C	1:0.55:3.24	8.9	0.02	50.2	0.22	1.75	163.0	Very good, sticky, rich
Z-BS-A	1:1.43:1.59	9.2	0.02	50.0	1.20	2.00	145.0	Good, rich
Z-BS-B	1:1.43:1.59	9.2	0.02	50.3	1.00	1.94	145.0	Good, rich
Z-BS-C	1:1.43:1.59	9.1	0.02	49.5	1.99	1.94	143.5	Very good, rich
Z-BS-D	1:1.43:1.59	9.2	0.02	50.4	0.80	1.87	145.3	Good, rich
P-BS-A	1:1.55:1.72	9.0	0.02	41.4	2.77	2.75	147.2	Good, sticky
P-BS-B	1:1.55:1.72	9.0	0.02	44.0	1.50	2.50	148.0	Good, sticky
P-BS-C	1:1.55:1.72	9.0	0.02	43.9	1.50	2.25	148.5	Good, sticky
L-BS-A	1:1.38:1.61	9.6	0.02	40.2	0.00	0.50	147.5	Very poor,
L-BS-B	1:1.38:1.61	9.6	0.02	41.3	3.30	3.00	148.0	excess bleeding,
L-BS-C	1:1.38:1.61	9.6	0.02	38.9	2.10	2.25	149.0	quick set b/
L-BS-D	1:1.38:1.61	9.6	0.02	39.9	3.10	2.83	148.0	
Z-B-A	c/1:0.86:0.66:0.99	9.1	0.02	62.0	3.30	2.00	131.0	Fair, harsh mix
Z-B-B	1:0.86:0.66:0.99	9.1	0.02	61.5	3.50	2.00	130.5	Fair, harsh mix
Z-B-C	1:0.86:0.66:0.99	9.1	0.02	59.5	4.50	2.25	129.5	Fair, harsh mix
L-B-A	1:0.82:0.63:0.95	9.5	0.02	64.8	1.75	3.25	132.5	Poor, quick set, bleeding
L-B-B	1:0.82:0.63:0.95	9.3	0.02	62.0	4.70	4.50	129.0	Fair, quick set, bleeding
L-B-C	1:0.82:0.63:0.95	9.4	0.02	63.0	3.45	3.00	130.5	Fair, quick set, bleeding

a/ The first letter indicates the type of cement, namely: P=portland, Z=portland-pozzolan; L=lumnite
The second letter of letters indicate the type of aggregate: O=olivine; BS=bluestone; B=building brick
The third letter indicates different batches of the same concrete. Several batches of each concrete were necessary to cast the required amount of specimens.

b/ All specimens fabricated from this concrete were discarded due to a partial set while placing which resulted in poorly fabricated specimens.

c/ Cement : Fine : Medium : Coarse aggregates,

Laboratory identification a/
Z-O-1
Z-O-2
Z-O-3
Z-O-4
Z-O-5
P-O-1
P-O-2
P-O-3
P-O-4
P-O-5
Z-BS-1
Z-BS-2
Z-BS-3
Z-BS-4
Z-BS-5
P-BS-1
P-BS-2
P-BS-3
P-BS-4
P-BS-5
Z-B-1
Z-B-2
Z-B-3
Z-B-4
Z-B-5
L-B-1
L-B-2
L-B-3
L-B-4
L-B-5

a/ The first lett
The second let
The numerals i
respective

b/ All blank spac

c/ Specimens were
were held a

d/ Cement : Fine

Table 2. Properties of cured and heat treated concretes

Laboratory identification a/	Proportions by weight. Cement to fine and to coarse aggregate	Compressive strength 6x12 in. cylinders	Flexural strength 6x6x36 in. beam b/	Abrasion loss	Young's Modulus of Elasticity		Linear shrinkage after heating	Weight loss during heating
					Dynamic	Longitudinally		
					Before heating	After heating c/		
		lb/in^2	lb/in^2	gm	$lb/in^2 \times 10^6$		%	%
Z-O-1	1:0.58:3.40	4205	425	45.5	5.190	—	—	—
Z-O-2	do	—	600	56.6	5.138	3.585	0.18	5.40
Z-O-3	do	—	455	73.2	5.257	2.736	0.02	4.48
Z-O-4	do	—						
Z-O-5	do	—						
P-O-1	1:0.55:3.24							
P-O-2	do							
P-O-3	do							
P-O-4	do							
P-O-5	do							
Z-BS-1	1:1.43:1.59	4620	405	15.2	5.132	—	—	—
Z-BS-2	do	—	360	23.0	5.273	2.694	-0.16	5.39
Z-BS-3	do	—	155	25.9	4.876	0.702	-0.73	6.43
Z-BS-4	do	—						
Z-BS-5	do							
P-BS-1	1:1.55:1.72	4000	420	14.9	5.470	—	—	—
P-BS-2	do	—	340	13.1	5.710	3.051	-0.18	4.78
P-BS-3	do	—	150	28.1	5.647	0.689	-1.04	6.25
P-BS-4	do							
P-BS-5	do							
Z-B-1	d/ 1:0.86:0.66:0.99	4890	395	15.7	2.700	—	—	—
Z-B-2	do							
Z-B-3	do							
Z-B-4	do							
Z-B-5	do							
L-B-1	1:0.82:0.63:0.95	5300	300	26.3	2.733	—	—	—
L-B-2	do							
L-B-3	do							
L-B-4	do							
L-B-5	do							

a/ The first letter indicates the type of cement, namely: P=portland; Z=portland pozzolan; L=Lumnite
The second letter or letters indicate the type of aggregate: O=olivine; BS=bluestone; B=building brick
The numerals indicate: 1=cured to 28 days only; 2,3,4, and 5 = cured to 28 days and heat treated at 250°C, 500°C, 750°C, and 1000°C respectively, for 5 hours.

b/ All blank spaces indicate that specimens have been fabricated and cured but not heat treated and tested.

c/ Specimens were heated at an approximate rate of 50°C per hour to maximum temperature. After equilibrium was reached they were held at this temperature for 5 hours. (See note a/ for details of heat treatments.

d/ Cement : Fine : Medium : Coarse aggregates.

BIBLIOGRAPHY

[1] ASTM Standards on Mineral Aggregates, Concrete and Nonbituminous Highway Materials, September, 1948.
Slump test for Consistency of Portland Cement Concrete, page 115.
Flexural Strength of Concrete (Using simple beam with third-point loading) page 101.

[2] National Bureau of Standards Report 1817.

[3] National Bureau of Standards Report 2003.

THE NATIONAL BUREAU OF STANDARDS

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